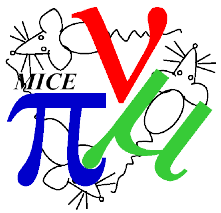


MICE
RF Controls
and
Instrumentation

6 December 2014

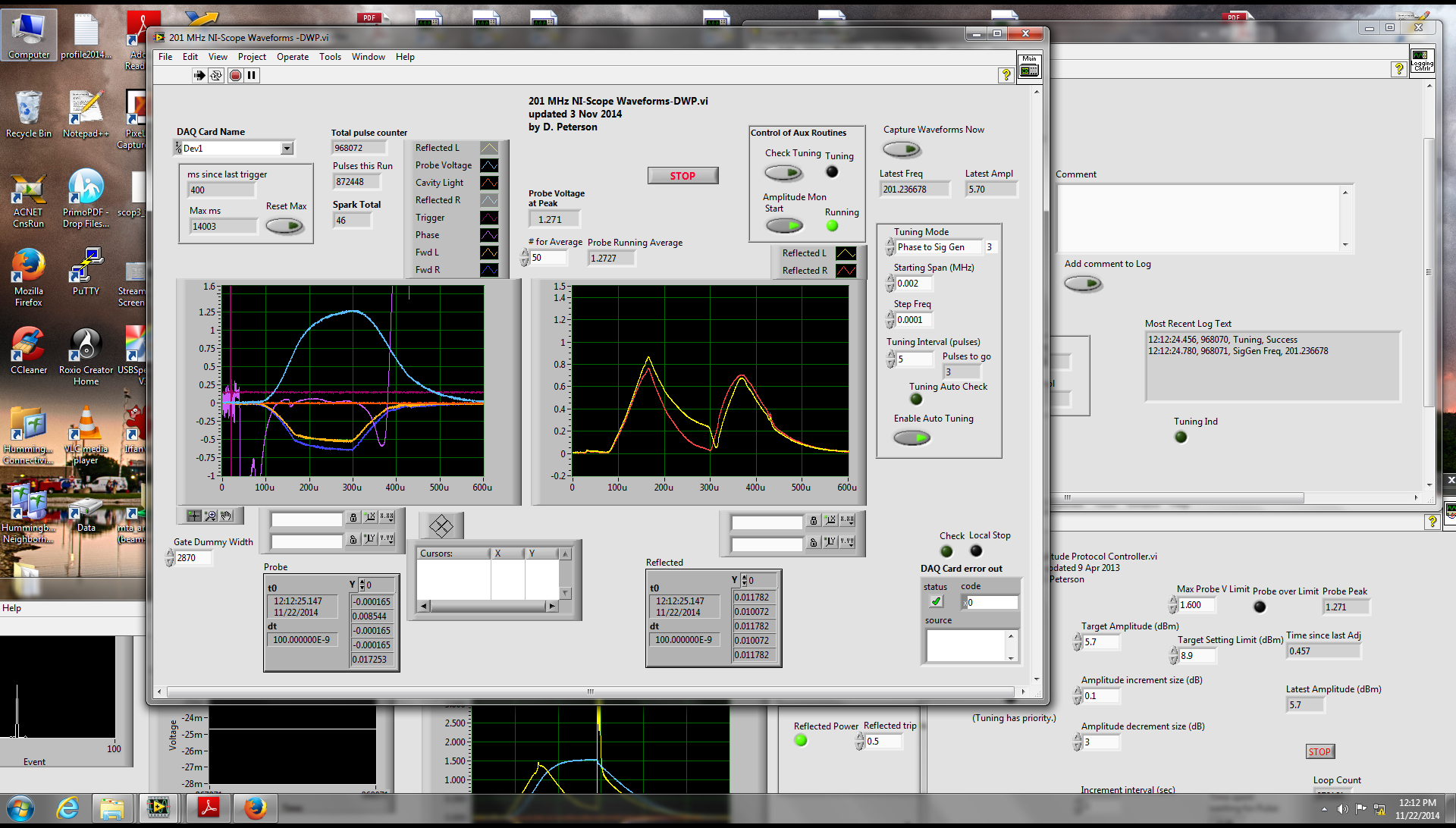
Dave Peterson

Fermilab

Introduction

- The MICE 201 MHz RF Control is a LabVIEW system similar to the one developed for 805 MHz cavity conditioning.
- New features include:
  - Amplitude control via Modulator.
  - Faster frequency setting via Digital Synthesizer.
  - Additional channels of data acquisition.
  - Phase detector for fast tuning.
  - Ability to tune the cavity using pneumatic actuators.

LabVIEW RF Controls

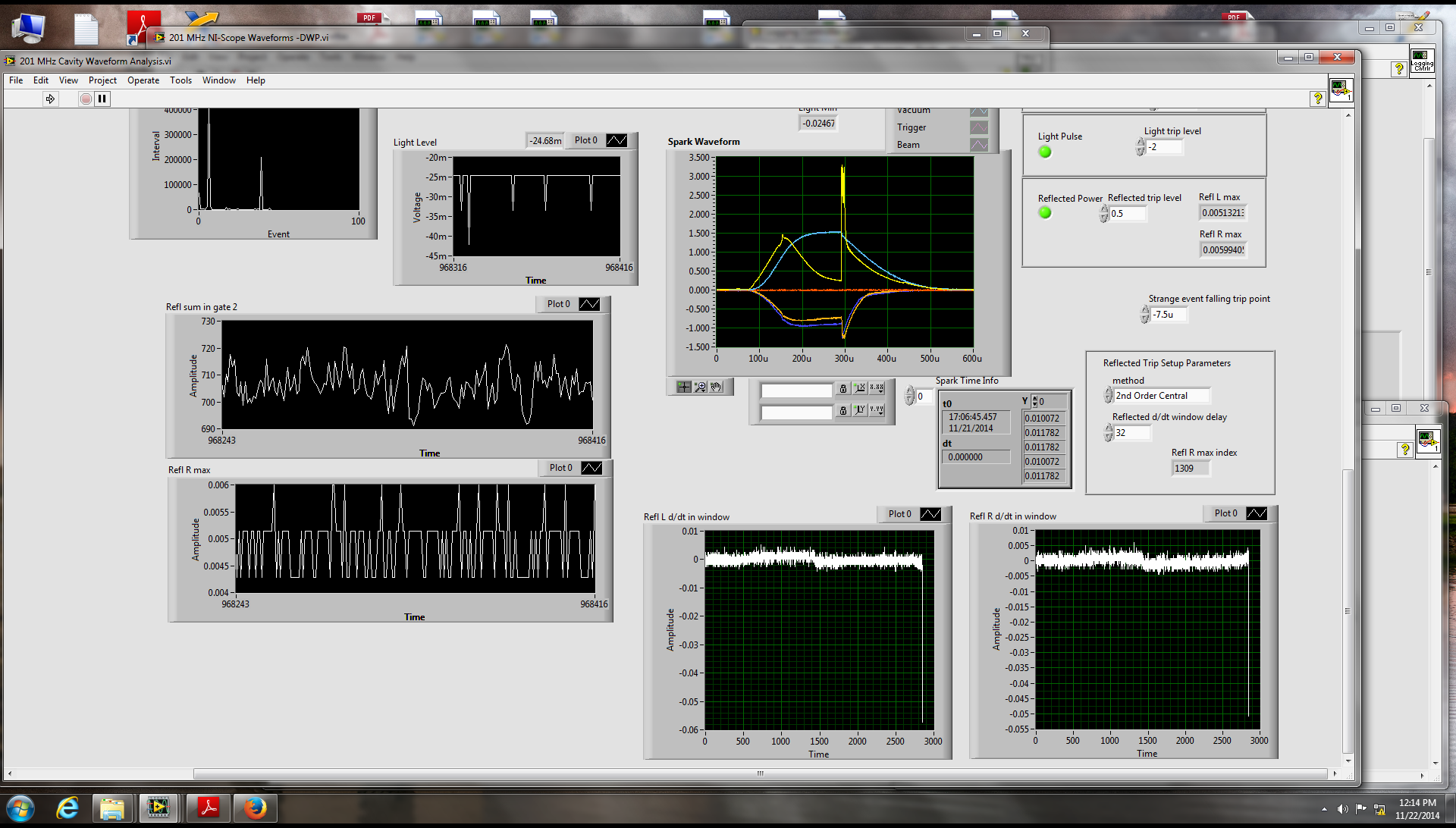


Main window shows Probe Voltage, Phase, and Forward powers in the left plot. Reflected powers are in the right plot.

LabVIEW RF Controls – Cavity Phase Control

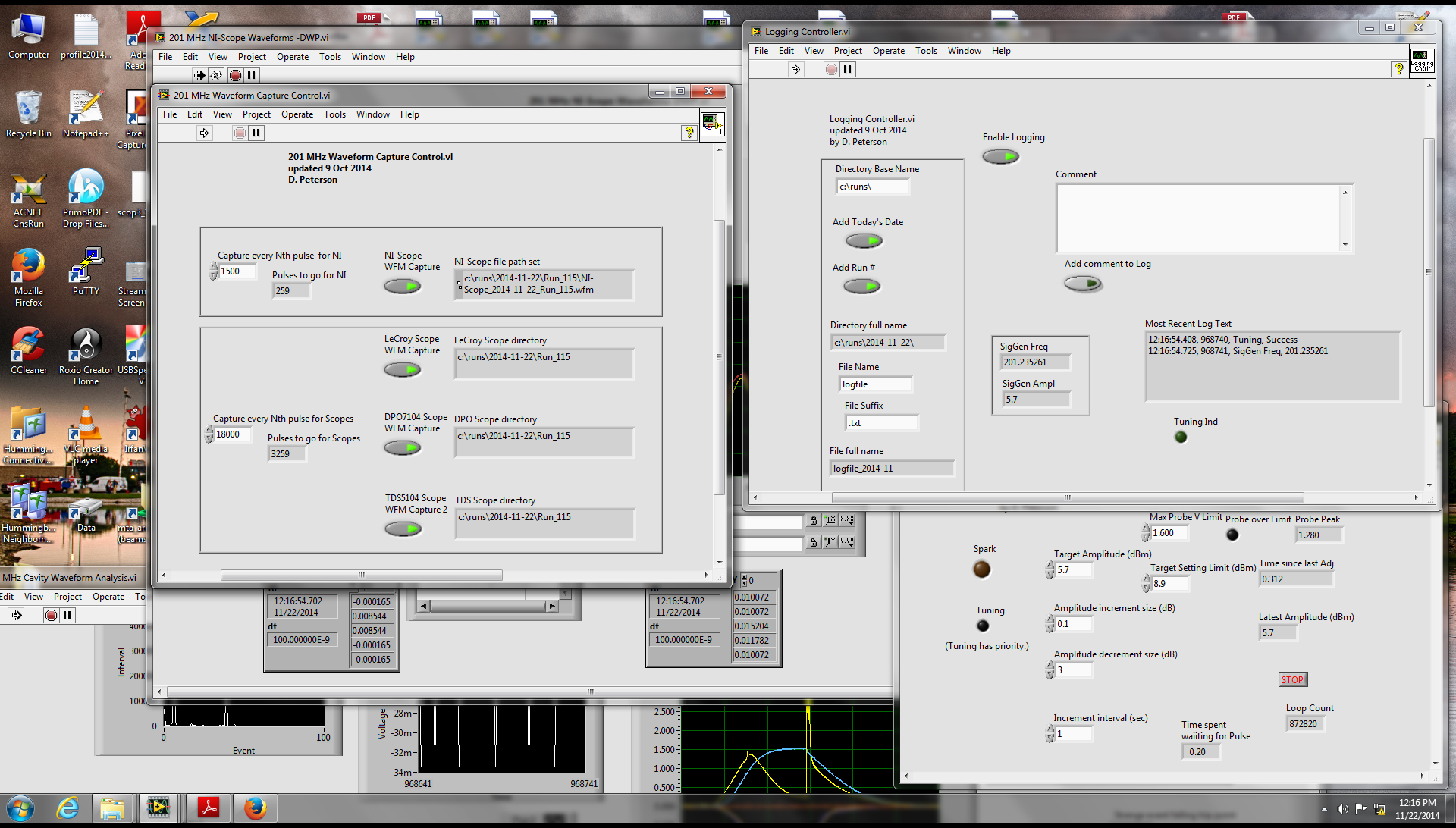
Phase is averaged over a gate width (500 points here) during the peak of the probe signal.

LabVIEW RF Controls – Cavity Waveform Analysis



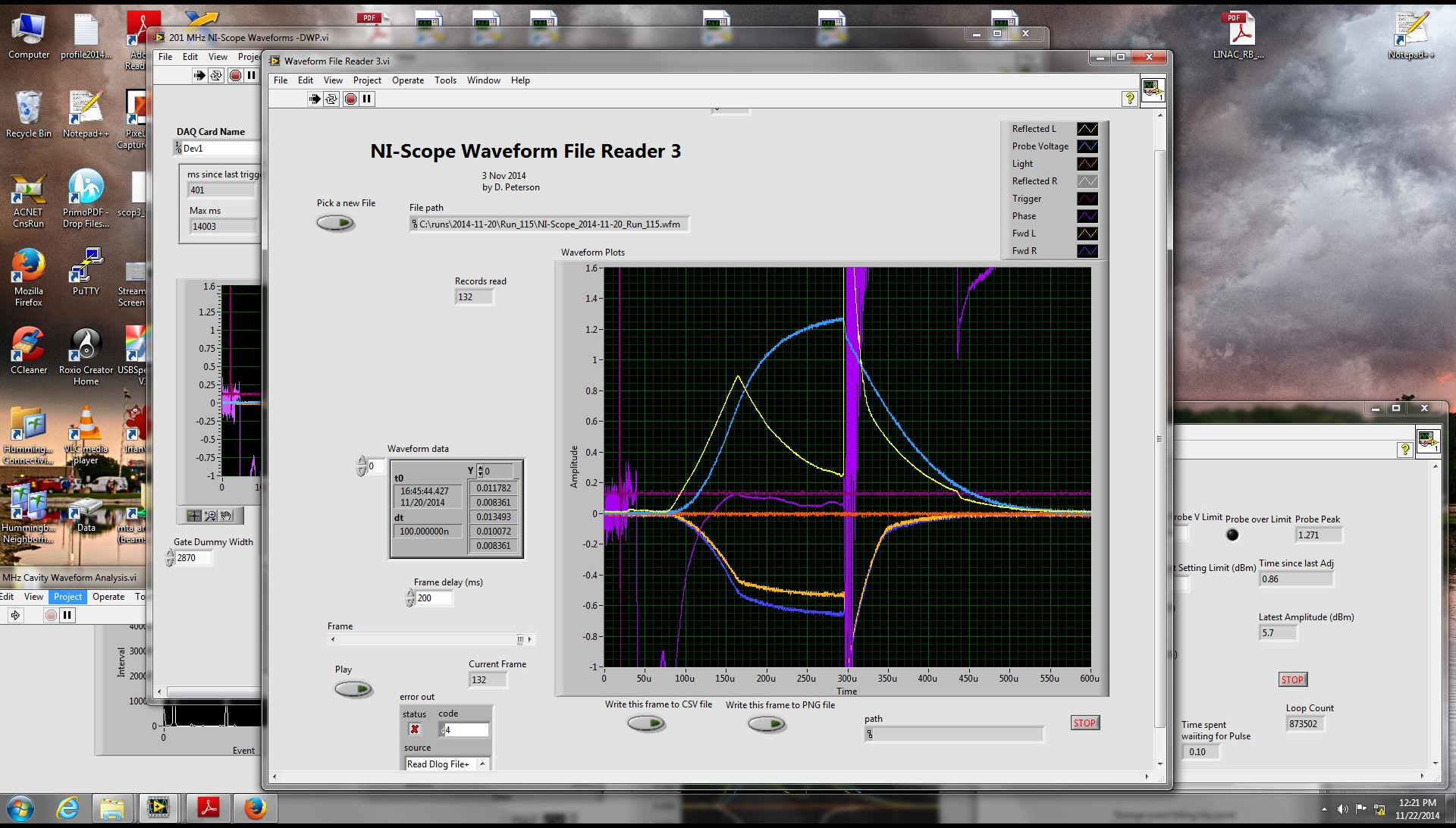
This performs all the waveform measurements and determines if a spark has occurred.

LabVIEW RF Controls – Waveform Capture and Logging



Oscilloscope capture interval and directories are set here.
Logging window provides a place for comment entries.

LabVIEW RF Controls – Waveform File Reader



This plays back captured waveform files and allows for saving frame data or pictures.

Amplitude Control

- Fermilab Linac 201 MHz RF station uses 7835 triode capable of 5 MW pulsed.
- Tube operates Class C so amplitude control is achieved by scaling modulator ramp signal.
- Ramp is ~300µS trapezoid with ~140µS flattop.
- LabVIEW controls USB digital to analog converter input to high speed analog multiplier chip.

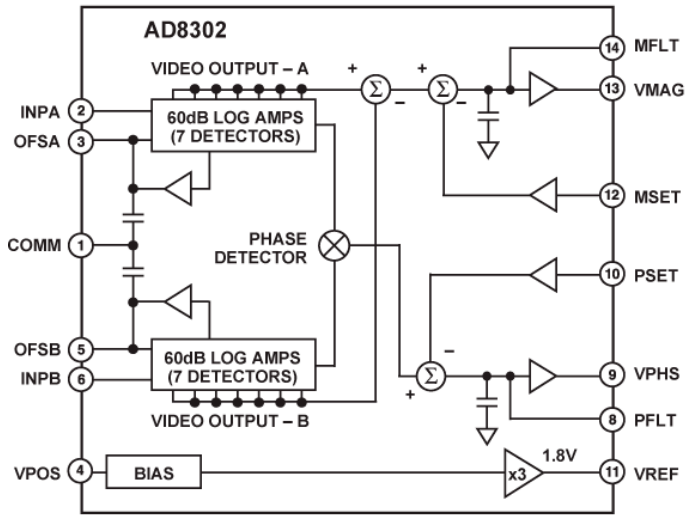
Linac
Station 7
Modulator
and
7835 Triode

Frequency Control

- Novatech 400 MHz Direct Digital Synthesizer.
- Fast settling.
- Phase continuous tuning.

Phase Detector

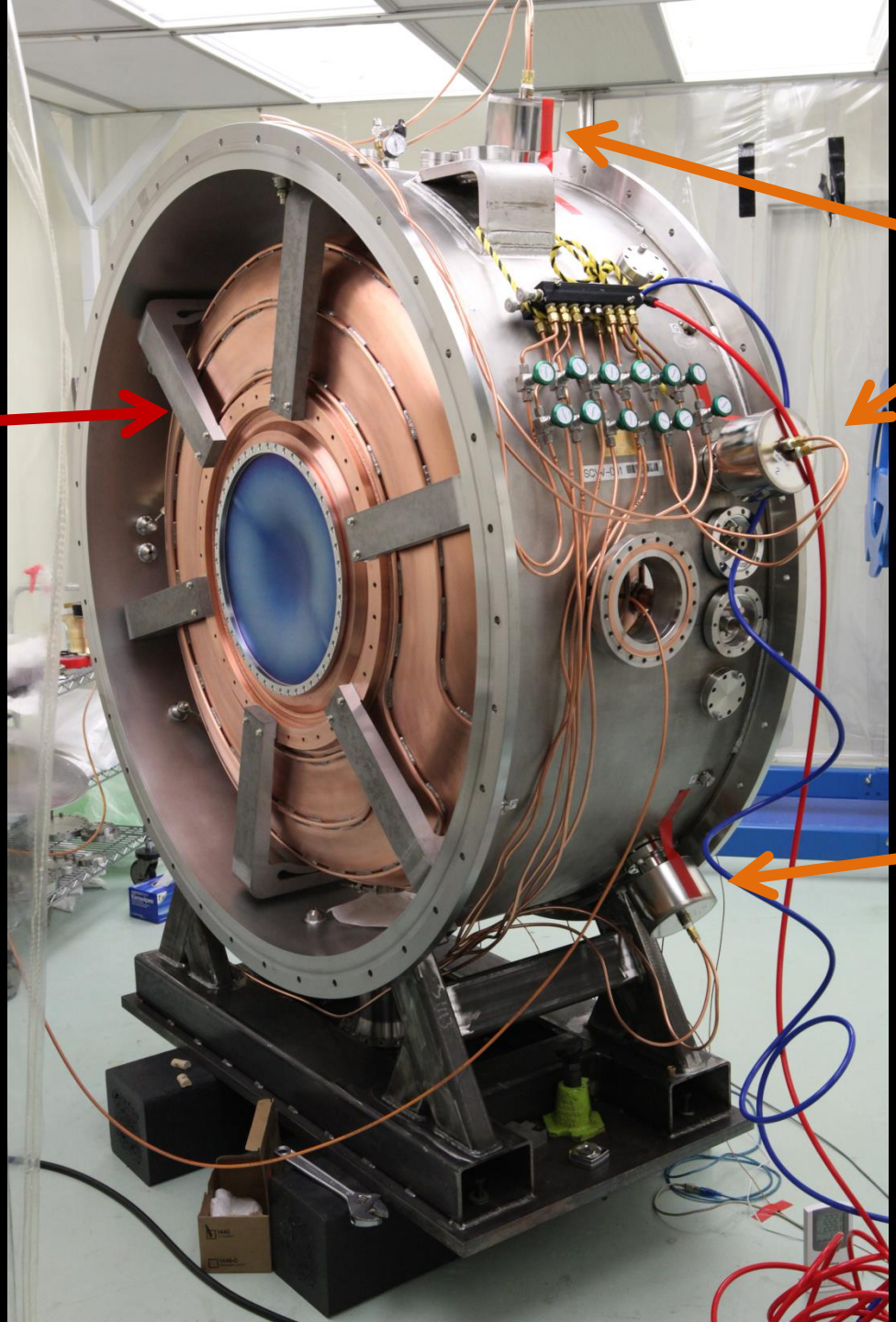
- Compares phase between RF Forward Drive signal at directional coupler nearest cavity and Cavity Probe Signal.
- Uses Analog Devices AD8302. Wide dynamic range and fast output.



Tuner Control

- LabVIEW communicates to Programmable Logic Controller (PLC). PLC speaks Modbus protocol to pneumatic proportional valves.
- Presently 5 of the 6 actuators are operational.
- Available nitrogen pressure is 78 PSI. System can handle up to 100 PSI.
- Tuning sensitivity is roughly 4 kHz/PSI.

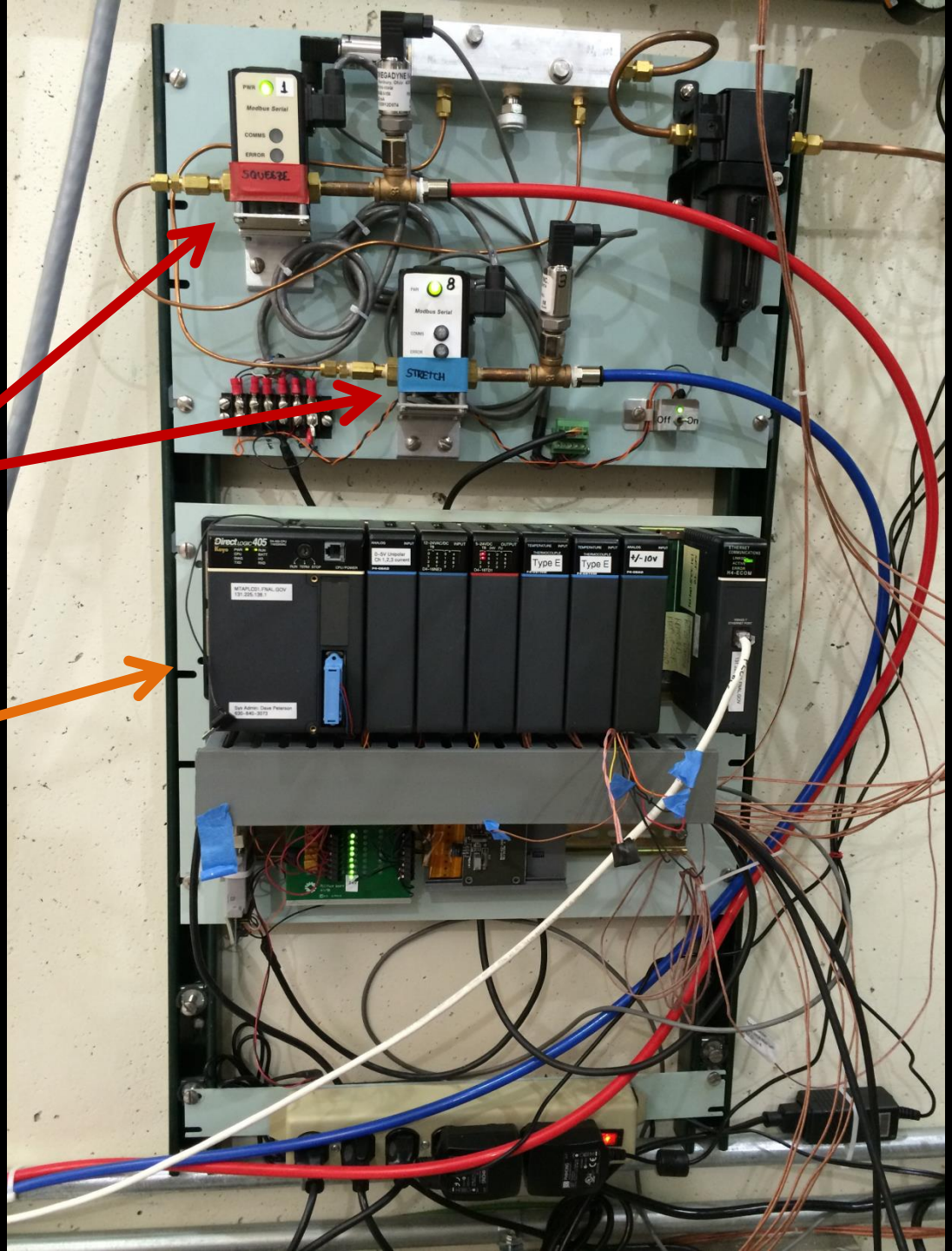
Mice Cavity Tuner Configuration



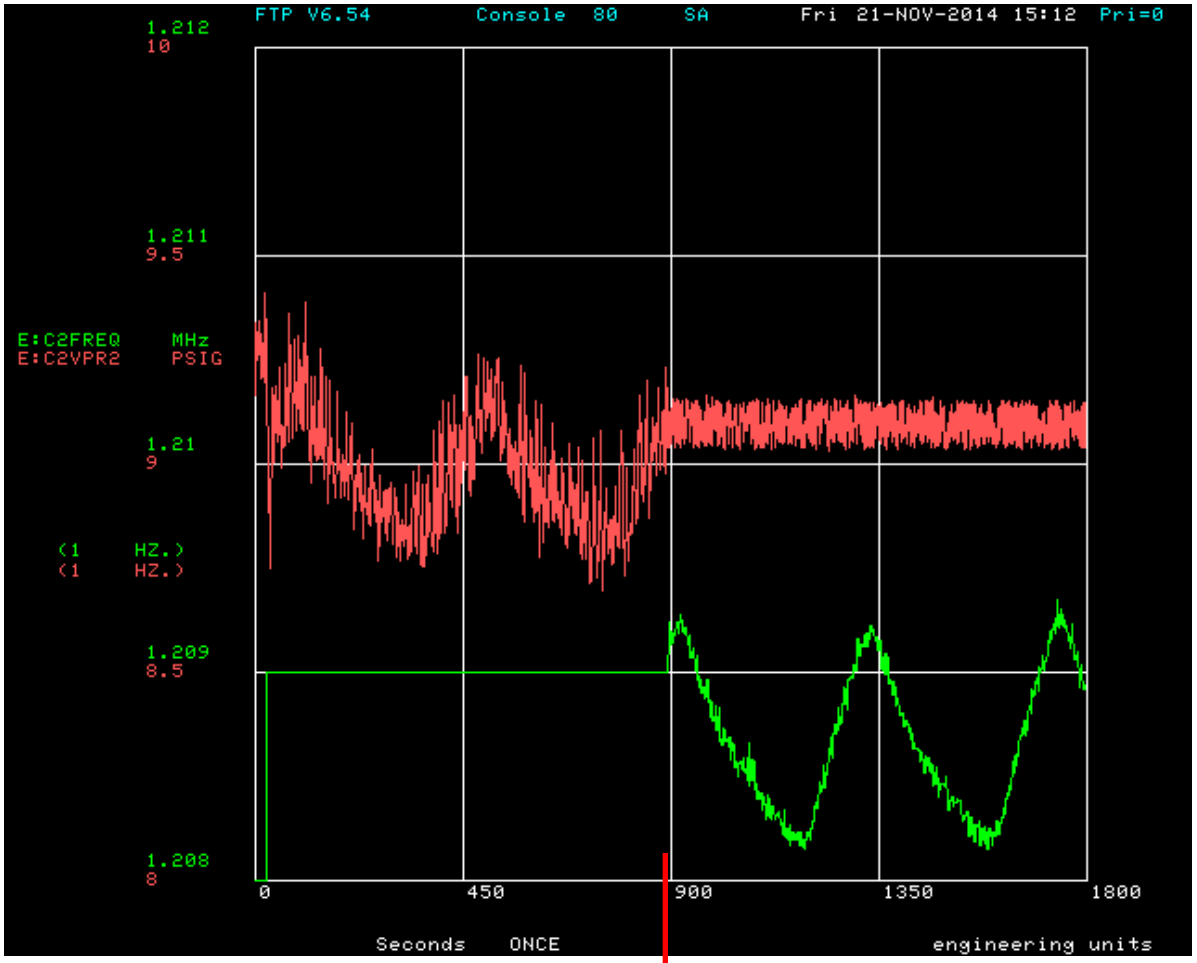
Mice Cavity Tuner Controls

Proportional Valves

PLC

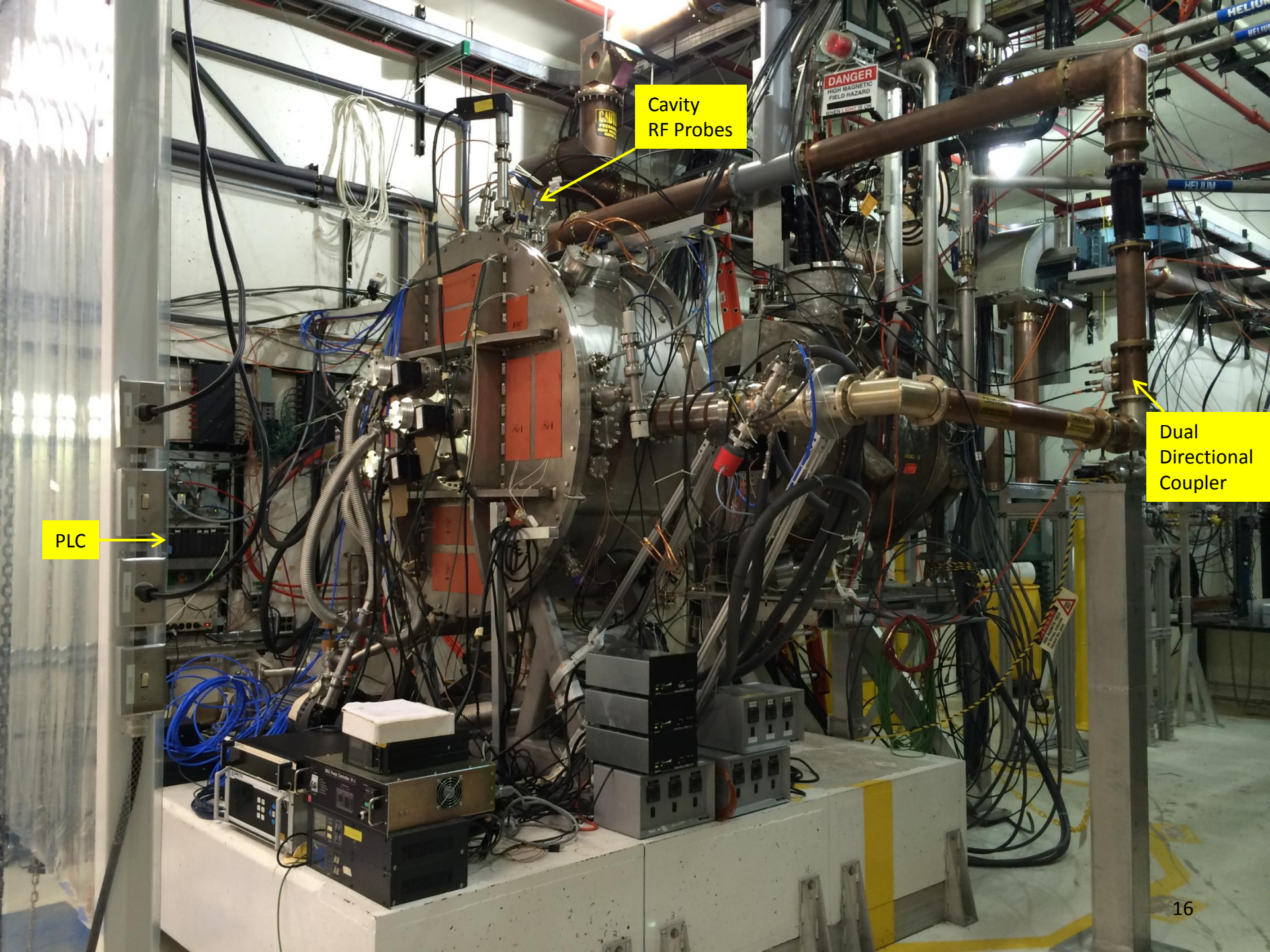


Tuner Test



Constant Frequency with pressure tracking

Constant Pressure with frequency tracking


Cavity
RF Probes
Dual
Directional
Coupler
PLC
DANGER
HIGH MAGNETIC
FIELD HAZARD

Tuning Comments

The Stretch and Squeeze directions of the tuner forks have slightly different pressure to frequency conversion. The pneumatic proportional valves pressurize the actuators much more slowly than they vent. Crossing over from Stretch to Squeeze has some deadband. The proportional valves have non-linear behavior at <1 PSI. This leads to four gains for tuner control plus some erratic behavior around zero PSI.

Hardware Notes

- LabVIEW data acquisition uses a National Instruments PCI-5105 8 channel card.
- RF signals into LabVIEW are from Advanced Control Components ACSP2615NZ diode detectors.
- Amplitude Control card uses an AD734 analog multiplier and an HI-5050 analog switch.

Acknowledgements

A huge debt of gratitude to the MICE Collaboration members near and far for the design and construction of all the components used in the cavity.

Many thanks to the Fermilab Linac Group for keeping Station 7 repaired and running.

Much of the tuner installation, software development and detailed test was done by Luca Somaschini for his thesis project.

The large cast of MTA Shift Workers have provided valuable assistance with installation and many helpful suggestions for software improvements.